| Los Alamos National Laboratory<br>**Environmental Restoration Project**<br>**Standard Operating Procedure** | No: LANL-ER-SOP-10.07 Rev: 1 |
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# Field Monitoring for Surface and Volume Radioactivity Levels

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| Prepared by | JOHN MANN<br>(Print Name) | (Signature) | 9-23-96<br>(Date) |
| Quality Review by | Patricia F Goldberg<br>(Print Name) | (Signature) | 9/27/96<br>(Date) |
| Technical Review by | Pat LaFrate<br>(Print Name) | (Signature) | 9-19-96<br>(Date) |
| PM Approval | JORG JANSEN<br>(Print Name) | (Signature) | 3-19-97<br>(Date) |
| QPPL Approval | Lawrence A. Souza<br>(Print Name) | (Signature) | 3/14/97<br>(Date) |

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# FIELD MONITORING FOR SURFACE AND VOLUME RADIOACTIVITY LEVELS

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# FIELD MONITORING FOR SURFACE AND VOLUME RADIOACTIVITY LEVELS

## 1.0 PURPOSE

This procedure describes the process of monitoring potentially contaminated equipment and materials, including waste, by use of both field counting of smear survey samples for removable contamination and direct field surveys for fixed (and/or total) contamination. Specifically, it allows waste management personnel to determine the levels of surface and bulk (volume) radioactive contamination for the potential release of non-radioactively contaminated material for public landfill disposal or beneficial use in accordance with Laboratory Procedure LP107-04.1, "Releasing Materials and Equipment" (LANL 1995). The main criteria for determining these levels are the decision amount (DA) and the minimum detectable activity (see Section 4.1).

## 2.0 SCOPE

### 2.1 Applicability

This procedure applies to the use of field instruments for determining radioactive contamination in Environmental Restoration (ER) Project wastes at Los Alamos National Laboratory (Laboratory). It is applicable to the requirements of Sections 7.2.2 and 7.2.3 of LS105-05.0, 7-1-96 (LANL 1996). These wastes include those generated during Resource Conservation and Recovery Act (RCRA) facility investigations, RCRA closures, corrective actions, and decommissioning.

Field screening may not be appropriate for sites whose radioactive materials content has not been adequately characterized, or where the contaminant is a pure alpha or beta emitter. Laboratory analyses may not be feasible for characterizing certain items, such as the interior of liquid drum samplers or plastic tubing used to convey groundwater during the purging, sampling, or development of monitoring wells. These types of items may be characterized as non-radioactive by using site sample results or process knowledge. Documentation of these data used for "free or conditional" release shall be in accordance with LP107-04.1, "Releasing Materials and Equipment."

### 2.2 Training

The field project leader (FPL) or equivalent is responsible for ensuring proper implementation of this procedure. The FPL also must ensure that he or she and all Radiological Control Technicians (RDTs) document that they read and

understand this procedure, the other applicable procedures in Section 1.0, General Instructions, of the ER Standard Operating Procedures, and the associated LANL Radiation Protection Program Documents.

An RCT certified by the Laboratory and the Laboratory Health Physics Operations Group (ESH-1) must make the radioactivity determinations described in this procedure. The RCT must meet the qualification requirements specified in the LANL Radiological Control (RadCon) Manual, Chapter 6, Part 4, Paragraph 641 through 645 (LANL 1994b).

## 3.0 DEFINITIONS

A. Background: Radiation from radioactive material other than that resulting from US Department of Energy (DOE) operations at the Laboratory. Background radiation includes radiation from cosmic rays and from naturally occurring radioactive materials in the earth and building materials, including radon (except as a decay product of source or special nuclear material) and global fallout as it exists in the environment from the testing of nuclear explosive devices (DOE/AL 1993). Background is determined using statistically sound methods of sampling and sample counting so as to duplicate the soil or material type of the suspected contaminated material but without including the actual suspected contaminated soil/material (see Section 6.1).

B. Decision amount (DA): The activity level above which the material being measured is considered "radioactive" at the 95% confidence level (Brodsky 1991).

C. Minimum detectable activity: The amount of activity that would be present in a sample to give a count less than the DA only 5% of the time, for a specific instrument (Brodsky 1991).

D. Surface contamination: Contamination found solely on the surface of, rather than throughout, the subject material.

- Σ Fixed. Contamination that can only be removed from surfaces by destructive means (such as grinding or chipping).

- Σ Removable. Radioactive material that can be removed from surfaces by nondestructive means, such as casual contact, wiping, brushing, or washing.

E. Volume contamination: Radioactive contamination dispersed throughout a matrix in excess of the appropriate release criteria. Examples of volume contamination are contaminated liquids and soils, materials activated by irradiation (for example, beams of charged particles), and smelted metals (where the smelting process incorporates radioactive material into the matrix of the metal).

# 4.0 BACKGROUND AND/OR CAUTIONS

## 4.1 Determining Radioactivity Level

DOE defines waste as nonradioactive if it contains no measurable increase in radioactivity above background (at a statistically defined confidence interval) in volume or bulk resulting from DOE operations at the Laboratory and contains no surface radioactivity above the limits specified in "Application of DOE 5400.5 Requirements for Release and Control of Property Containing Residual Radioactive Material," DOE Memorandum, 11-17-95 (DOE 1995) (see Attachment B). Therefore, bulk- or volume-contaminated wastes will be classified as radioactive if the wastes are statistically above applicable background levels. Surface-contaminated wastes will be classified as radioactive in accordance with LP107-04.1.

Deciding whether waste or other material is contaminated with radioactivity requires that radiation detection instruments be used to determine the background count in the vicinity of the waste or other material. This count must then be compared with the count of a sample of the material in question. The sample count must have a certain value above the background count in order to be called "radioactive" with an agreed-upon degree of certainty or confidence that the result is correct. This value is called the decision amount (DA) (Brodsky 1991). Likewise, if the sample count is less than this certain value, it is called "nonradioactive" (or "at background") with the same degree of confidence.

The DA is the smallest measure of radioactivity or the level closest to background with which a decision of contamination can be made at an acceptable confidence level of 95%. This means that the DA is the amount of activity that would give an average count *greater* than the DA value only 5% of the time (see Attachment A, Type I error).

The DA does not indicate how much activity would have to be in the sample to give a count *less* than the DA only 5% of the time (which is assuming something is not there when it is there). This leads to the use of the minimum detectable activity, which is an amount of activity in a sample that will be called *greater* than the DA 95% of the time. This leaves only a 5% chance that the activity would count *less* than the DA and would be called background (see Attachment A, Type II error).

### 4.1.1 Surface Contamination

DOE allows the release of material and equipment for unrestricted use if the items have surface contamination below specific levels listed in DOE Order 5400.5, Fig. IV-1, (DOE 1990) as modified by the US Atomic Energy Commission Regulatory Guide 1.86 (AEC 1974) and DOE

Memorandum, Application of DOE 5400.5 Requirements for Release and Control of Property Containing Residual Radioactive Material, November 17, 1995 (DOE 1995) (see Attachment B). This approach will be applied to potentially surface-contaminated ER Project wastes. The wastes will be classified as radioactive if the wastes are above the criteria as specified in LP107-04.1. The wastes will be classified as "uncontaminated" (and can be considered nonradioactive) if the wastes are below the DOE criteria.

The decision of whether a smear sample or a direct measurement of a surface is contaminated is based on a comparison of the relative counts obtained on the instrument with background and blank sample count rates (Attachment A). The level of radioactivity at which this decision is made must be below the contamination guidelines shown in Attachment B so that material may be released for unrestricted use with a high degree of confidence that it is not contaminated. If a smear sample or direct measurement indicates contamination, it will not be judged as uncontaminated with the same degree of confidence. This decision level is defined in this procedure as the minimum detectable activity of each instrument used to measure the type of radiation emitted by the isotopes in question.

To determine if surface-contaminated wastes are radioactive, the minimum detectable activity must be calculated and the counting times adjusted to ensure that the instrument is capable of detecting radioactivity at levels less than the amounts in Attachment B with a high degree of confidence. This determination is based upon measurements taken with a field instrument having a standard minimum detectable activity at the 95% confidence interval below the levels required by the table in Attachment B.

### 4.1.2 Bulk or Volume Contamination

For potentially contaminated bulk waste, other than concrete or masonry, that can readily be sampled (such as soil), a known sample of uncontaminated material is counted with a geometry identical to that of the sample in question. The background must be determined in a noncontaminated location at the site or by using a noncontaminated soil or other waste sample taken from the site. (See Section 6.1.)
The minimum detectable activity must then be calculated and the counting times adjusted to ensure that the instrument is capable of detecting radioactivity at levels less than the amounts in Attachment B with a high degree of confidence. This determination is based upon measurements taken with a field instrument having a standard minimum detectable activity at the 95% confidence interval below the levels

required by the table in Attachment B. The radioactivity status is determined by calculating the minimum detectable activity using the counts measured with a radiation survey meter. If the radioactivity levels are above the minimum detectable activity, the wastes will be classified as radioactive.

For concrete and masonry block determinations, the background and the radioactivity status are determined as described in Sections 6.1.2 and 6.4. A background survey shall be performed to determine the concentrations of naturally occurring radioactive material in concrete and masonry block building debris generated by a particular demolition project. Because guidelines for residual radioactivity at decommissioned sites are presented in terms of activity levels above normal background, background determinations are necessary. Background measurements shall be taken on concrete/masonry block debris taken from unaffected areas of a particular site that have no history of radioactive material use.

## 5.0 EQUIPMENT

Counting Equipment for $\alpha$–$\beta$ Surface Smear Samples for Determining Removable Surface Contamination Levels

- Ludlum Model 2929 $\alpha$–$\beta$ Sample Counter (with attached Model 43-10-1 $\alpha$–$\beta$ sample counter) or the equivalent

Survey Equipment for Measuring Direct $\alpha$–$\beta$ Surface Contamination Levels

- Ludlum Model 12 Survey Meter w/ Model 43-5 or 43-90 Alpha Scintillator or equivalent (for a contamination) or Model 44-9 $\alpha$–$\beta$ pancake detector or equivalent (for $\beta$–$\gamma$ contamination)

Survey Equipment for Soil or Other Material Suspected of Plutonium or Americium Contamination

$\Sigma$ Ludlum Model 2221 Scaler/Ratemeter (or the equivalent) used with Teledyne Isotopes NaI (Tl) FIDLER detector (or equivalent)

Survey Equipment for Other Gamma-Ray Radionuclide Contaminants

- Ludlum Model 2221 Scaler/Ratemeter with Model 44-10 2x2 Gamma Scintillator

- Ludlum Model 19 MicroR Meter

# 6.0 PROCEDURE

## 6.1 Determination of Background Radioactivity

### 6.1.1 Smear and Direct Surface Contamination

To be performed in accordance with Procedure LP107-04.1.

Prepare blank smear samples by smearing known noncontaminated items and counting in the smear counter for a or b or both, as appropriate. Count rates from these samples will be used for determining the natural background activity in the minimum detectable activity calculation. Record these data as described in ESH-1-02-02.

For direct surface-contamination background measurements, measure the "direct" radiation levels on uncontaminated items similar to those being checked to get background count values suitable for use in the minimum detectable activity calculation. Use the Ludlum Model 12 with either the a or b detectors or both, as appropriate.

### 6.1.2 Bulk or Volume Contamination

For concrete and masonry block debris, select a concrete slab and a masonry block from the concrete pile that will be used to determine background.

Take 10 direct measurements using the ESP-1 with a HP260 probe (or equivalent) on the concrete and masonry block. Based on the 10 direct measurements, record the average reading.

Take 10 direct measurements using the Ludlum 2221 with a ZnS 43-5 probe (or equivalent) on the concrete and masonry block. Based on the 10 direct measurements, record the average reading.

Take 30 background g measurements using a 2 in x 2 in NaI (T1) or equivalent detector connected to a portable rate meter instrument on contact with the concrete slab. Record the 30 measurements on a suitable survey form.

Use the Upper Bound of background Excel (spreadsheet (LANL 1996a) and determine the gross g upper bound background range for concrete gamma scanning operations.

Take 30 background g measurements using a 2-in. x 2-in. NaI (T1) or equivalent detector connected to a portable rate meter instrument on

contact with the masonry block. Record the 30 measurements on a suitable survey form.

Use the Upper Bound of background Excel( spreadsheet and determine the gross g upper bound background range for masonry block gamma scanning operations.

Take three random 300 gm or greater material samples of concrete and three random 300 gm or greater material sample of masonry from the samples above used in the background determinations and analyze them by gamma and alpha spectroscopy. Based on the three material sample analyses, background concrete radioactive isotope concentration shall be determined for the project.

For other materials readily sampled, such as soil, collect and count several representative samples of soil from outside the boundary of the known contaminated area but as close to the site as is reasonable, to approximate the type of soil to be analyzed. Use a sample container, such as a marinelli beaker or a stainless steel bowl, with at least 500 grams of soil or other similar material and a detector geometry identical to that used to calibrate the detector and to count the waste samples. The number of samples required depends upon the volume of soil to be measured for radioactivity. Count rates from these samples will be used for the background term in the minimum detectable activity calculation (see also LANL 1996b). Record these data as described in ESH-1-02-02.

### 6.2 Calculation of Minimum Detectable Activity

Calculation for minimum detectable activity where:

Minimum detectable activity in dpm/100cm$^2$
B= Background (zero activity sample) count rate in cpm
t = Sample counting time in minutes
E = Detector efficiency
A = Detector active area in cm$^2$

Determine the count rate of a blank ("zero-activity" or background) smear or an uncontaminated object similar to the one to be surveyed. Record as described in ESH-1-02-02.

Calculate the minimum detectable activity for each instrument/detector combination using the form in Attachment C. If the instrument minimum detectable activity is determined to be above the Attachment B value for the activity being measured, then increase the counting time or the detector active area until the instrument minimum detectable activity value is less than the

value in Attachment B. Sample locations are to be entered on Attachment C and on the data sheet used per ESH-1-02-02.

### 6.3 Determination of Surface Radioactive Contamination

Remove any bulk or volume contamination (i.e., soil, mud) from waste equipment or items, if practical. Refer to ESH-1-02-02, "Surveying for Alpha and/or Beta/Gamma Contamination" (LANL 1994a), for details. Calculate theminimum detectable activity of each survey instrument as described in Section 6.2. If the minimum detectable activity is less than the values in Attachment B, use the "removable" or "average" values in Attachment B as described below. If the instrument readings are less than the values in Attachment B, classify the wastes as nonradioactive.

Determine the removable contamination levels by smearing and following the technique described in Section 7.2 of LANL Procedure ESH-1-02-02 (LANL 1994a). If levels are above the "removable" levels in Attachment B, decontaminate before proceeding with direct measurements.

Once all measurements are completed, Procedure LP107-04.1 will be followed. Note that the contamination guidelines in Attachment 2 to LP107-04.1 are identical with the values in Attachment B to this procedure.

### 6.4 Determination of Bulk or Volume Radioactive Contamination

Procedure LP107-04.1 governs the radioactivity determination.

#### 6.4.1 Concrete Masonry Block Debris

Survey the concrete or masonry block with a 2-in. x 2-in. NaI (Tl) or equivalent detector connected to a portable rate meter instrument. If the survey does not find count rates that exceed 2 times the upper limit of background for the instrument, then the concrete should be considered below release criteria by the field survey.

If the field survey indicates activity greater than two times the upper limit of background, concrete or masonry block samples need to be analyzed by gamma spectroscopy. The analytical sensitivity should be less than 10% of project release criteria for that isotope.

#### 6.4.2 Other Waste Material

Use a sample container, such as a marinelli beaker or a stainless steel bowl, with at least 500 grams of soil or other similar material and a detector geometry identical to that used to calibrate the detector. The

number of samples required depends upon the volume of soil to be measured for radioactivity.

For g emitters, the Ludlum Model 2221 with the Model 44-10 (2 in. x 2 in.) scintillation detector is suitable for direct measurements on bulk samples as long as suitable calibrations for the type of emitter and the geometry are available. This does not apply to Pu/Am-contaminated bulk samples.

For suspected Pu/Am contamination other than smear samples, only the FIDLER detector is appropriate for small or distributed samples. Large containers of soil or other material cannot be measured in the field for Pu/Am contamination.

For tritium, pure alpha or beta-contaminated samples or material, routine field measurement techniques are not currently available. Samples must be analyzed with a laboratory-type counter.

### 6.4.3 Waste Classification

If the radioactivity levels are above the minimum detectable activity of the instrument, classify the waste as radioactive. If the radioactivity levels are below the minimum detectable activity, classify the waste as non-radioactive.

## 6.5 Quality Control

For bulk/volume measurements the instrument must be calibrated with a suitable radioactivity field standard prepared with either DU, natural uranium or other contaminant radionuclide, mixed with soil or whatever material is being surveyed, in a marinelli beaker or other suitable geometry. The preparation and calibration of this field standard is documented in accordance with ESH-4 calibration procedures. This calibration is in addition to the one performed by ESH-4 and is a field calibration for the specific contaminant. The instrument settings are not changed by this process; only the field conversion equation for Detector Efficiency (E) (See Attachment C) is modified for this particular application. The calculations are documented on Attachment C.

Prior to use, check each field instrument with a standard source that is independent of the calibration source. The value found for this check source must agree with the source by $\pm$ 20%. All values measured for this check source (even those outside the 20% criteria) shall be entered on the check sheets for each instrument. The check sheets are attachments to the ER Project Health Physics Method (ER-HPM) for the specific instrument being used. The ER-HPMs are Operational Checks of individual Ludlum Instrument Models numbered from ER-HPM-4 through ER-HPM-8 and are listed in the Reference

section of this procedure. These ER-HPMs are instrument specific for the ER Program and implement the requirements of ESH-1 Procedure ESH-1-07-85.1, "Operational Checks of Beta/Gamma Survey Instruments and ESH-1-07-86.1, "Operational Checks of Alpha Survey Instruments".

## 7.0 RECORDS

During implementation of this procedure, the form for the Determination of DA and minimum detectable activity (Attachment C) will be completed. The FPL is responsible for submitting copies of the completed form to the ER Record Processing Facility, MS M707.

Each direct or smear sample measurement result and the disposition of the item shall be recorded on the appropriate form as required by LP107-04.1. Release of material for public use or disposal must be documented. The FPL is responsible for submitting copies of the completed form to the ER Record Processing Facility, MS M707.

Records for release of material, equipment and waste must be managed in accordance with ESH-1-01-12, "Management of Radiological Records" (April 18, 1996).

## 8.0 REFERENCES

AEC (US Atomic Energy Commission), June 1974. "Termination of Operating Licenses for Nuclear Reactors," Regulatory Guide 1.86, Oak Ridge, Tennessee (AEC 1974).

Brodsky, A. and R.G. Gallaghar, "Statistical Considerations in Practical Contamination Monitoring," Radiation Protection Management, Vol. 8, No. 4, 1991 (Brodsky 1991).

Department of Energy, June 5, 1990. "Radiation Protection of the Public and the Environment," Order 5400.5, Washington, DC (DOE 1990).

Department of Energy/Albuquerque, 1993. "Performance Objective for the Waste Moratorium," US Department of Energy Albuquerque Operations Office (DOE/AL 1993).

Department of Energy, 1994. "Radioactive Waste Management," Draft Order 5820.2B, Washington, DC (DOE 1994).

Department of Energy, 1995. "Application of DOE 5400.5 Requirements for Release and Control of Property Containing Residual Radioactive Material," DOE Memorandum, 11-17-95 (DOE 1995).

Los Alamos National Laboratory, March 4, 1994. "Surveying for Alpha and/or Beta/Gamma Contamination," Environment, Safety and Health Procedure ESH-1-02-02, Los Alamos, New Mexico (LANL 1994a).

Los Alamos National Laboratory, December 23, 1994. "Radiological Control Manual," Los Alamos National Laboratory Manual LM107-01.1, Los Alamos, New Mexico (LANL 1994b).

Los Alamos National Laboratory, November 2, 1994. "Radiation Protection Program Documents" Laboratory Manual LM107-02.3, Los Alamos, New Mexico (LANL 1994c).

Los Alamos National Laboratory, September 29, 1995. "Releasing Materials and Equipment," Laboratory Procedure LP107-04.1, Los Alamos, New Mexico (LANL 1995).

Los Alamos National Laboratory, July 10, 1995, "Operational Check of the Ludlum Model 2929 Scaler", ER-HPM-4, Rev. 0.

Los Alamos National Laboratory, July 10, 1995, "Operational Check of the Ludlum Model 2221 Ratemeter/Scaler w/43-68 Gas Proportional Detector," ER-HPM-5, Rev. 0.

LANL (Los Alamos National Laboratory), July 10, 1995, "Operational Check of the Ludlum Model 3 Survey Meter," ER-HPM-6, Rev. 0.

Los Alamos National Laboratory, July 10, 1995, "Operational Check of the Ludlum Model 12 Survey Meter," ER-HPM-7, Rev. 0.

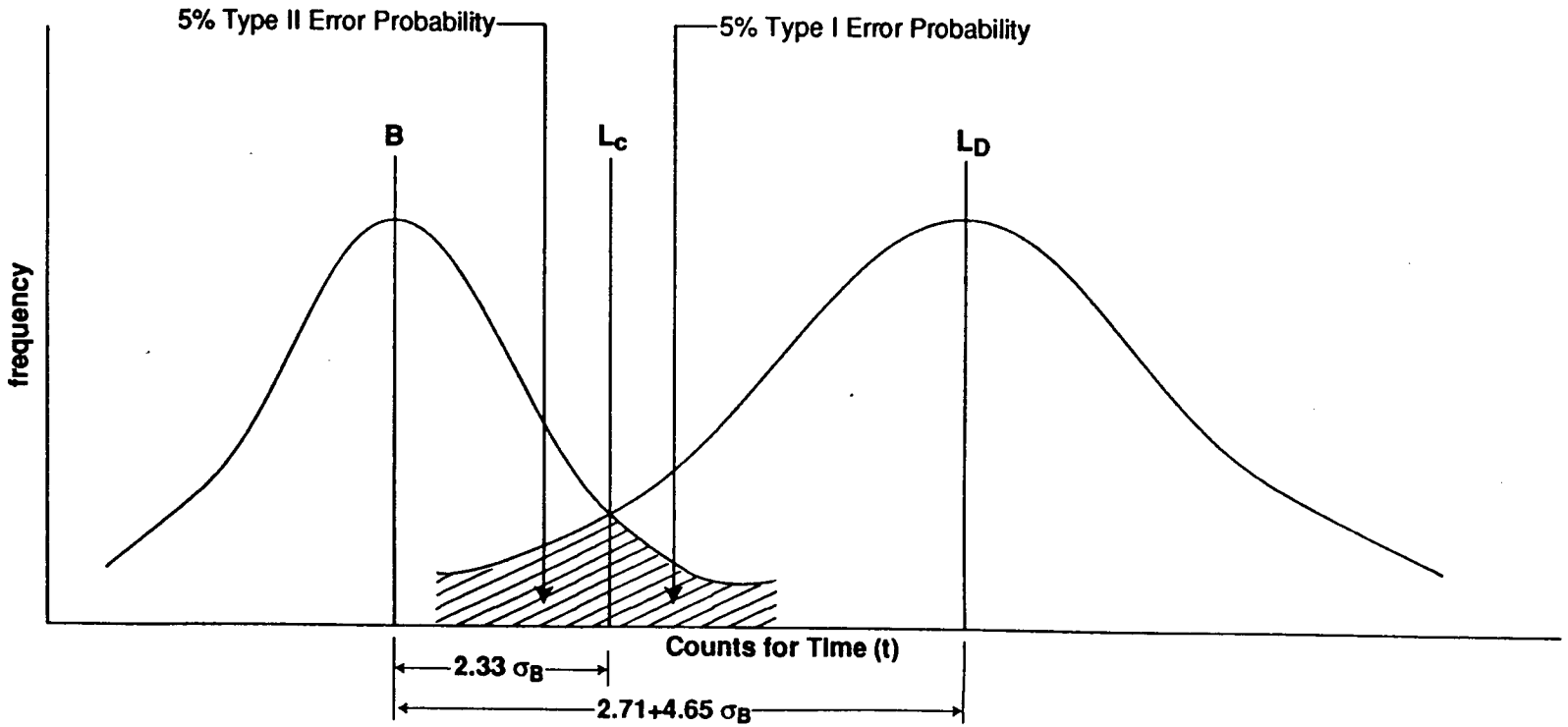
Los Alamos National Laboratory, July 10, 1995, "Operational Check of the Ludlum Models 12S and 19," ER-HPM-8, Rev.0.

Los Alamos National Laboratory, April 12, 1996. "Requirements for Verifying Demolition Concrete Debris Is Below Project Release Criteria and Suitable for Crushing and On-Site Fill," Environmental Restoration Project Method ER-HPM-11, Rev. 0 (LANL 1996).

## 9.0 ATTACHMENTS

Attachment A - Normal Distribution of Radioactivity Counts Graph
Attachment B - Surface Contamination Levels Table
Attachment C - Determination of DA and Minimum Detectable Activity

## Normal Distribution of Radioactivity Counts




B = blank sample count rate
$\sigma_B = \sqrt{Bt}$
$L_C$ = 2.33 $\sigma_B$ (the counts used to calculate the DA)
$L_D$ = 2.71+4.65 $\sigma_B$ (the counts used to calculate the MDA)

## Table 1. Surface Activity Guidelines
## Allowable Total Residual Surface Activity (dpm/100cm$^2$)[4]

| Radionuclides[5] | Average[6/7] | Maximum[7/8] | Removable[9/9] |
|---|---|---|---|
| Group 1 - Transuranics, I-125, I-129, Ac-227, Ra-226, Ra-228, Th-228, Th-230, Pa-231 | 100 | 300 | 20 |
| Group 2 - Th-natural, Sr-90, I-131, I-133, Ra-223, Ra-224, U-232, Th-232 | 1000 | 3000 | 200 |
| Group 3 - U-natural, U-235, U-238, and associated decay products, alpha emitters | 5000 | 15000 | 1000 |
| Group 4 - Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous[10] fission) except Sr-90 and others noted above | 5000 | 15000 | 1000 |
| Tritium (applicable to surface and subsurface)[11] | N/A | N/A | 10000 |

[4]As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive materials as determined by counts per minute measured by an appropriate detector for background efficiency, and geometric factors associated with the instrumentation.
[5]Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.
[6]Measurements of average contamination should not be averaged over an area of more than 1 m2. For objects of smaller surface area, the average should be derived for each such object.
[7]The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.
[8]The maximum contamination level applies to an area of not more than 100 cm$^2$.
[9]The amount of removable material per 100 cm$^2$ of surface area should be determined by wiping an area of that size with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wiping with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm$^2$ is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. It is not necessary to use wiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual surface contamination levels are within the limits for removable contamination.
[10]This category of radionuclides includes mixed fission products, including the Sr-90 tht is present in them. It does not apply to Sr-90 that has been separated from the other fission products or mixtures where the Sr-90 has been enriched.
[11]Property recently exposed or decontaminated should have measurements (smears) at regular time intervals to ensure that there is not a build-up of contamination over time. Because tritium typically penetrates material it contacts the surface guidelines in Group 4 are not applicable to tritium. The Department has reviewed the analysis conducted by the DOE Tritium Surface Contamination Limits Committee ("Recommended Tritium Surface Contamination Release Guides," February 1991), and has assessed potential doses associated with the release of property containing residual tritium. the Department recommends the use of the stated guidelines as an interim value for removable tritium. Measurements demonstrating compliance of the removable fraction of tritium on surfaces with this guideline are acceptable to ensure that non-removable fractions and residual tritium in mass will not cause exposures that exceed DOE dose limits and constraints.

**Los Alamos National Laboratory Environmental Restoration**
**DETERMINATION OF DA AND MINIMUM DETECTABLE ACTIVITY**

Date: _____

Technical Area_____ Operable Unit_____

Calibration procedures must be approved by ESH-4. Calibration results must be within acceptable parameters prior to using a specific instrument to document unrestricted release of materials and equipment. Declaration of waste as "non-radioactive" must be documented with appropriate laboratory or enhanced field analyses.

Instrument Type_____ Model Number_____

Serial Number:_____Calibration Date_____

Surveyor_____ _____
(Signature) Date (Print Name) Group

Background Count Rate _____cpm (B)

Background (or sample) Counting Time _____min. (t)

Detector Efficiency _____(E)

Detector Active Area _____$cm^2$ (A)

Calculate Minimum Detectable Activity

**Minimum detectable activity = _____dpm/100 $cm^2$**

Calculate Decision Amount (DA)

**DA = _____dpm/100 $cm^2$**

Calculations Checked by _____
(Print Name) Group

_____
(Signature) Date